REMARKS

Status of the Claims

Claims 1-30 were pending in this application. . Claims 1, 9, 11, 13, 16, 26, and 28 have been amended. Claims 31 and 32 have been added.

Amendments to the Specification

Paragraphs [0007], [0011, [0016] of specification and the title have been responsively amended to remove the informalities noted by the Examiner.

Amendments to the Claims Pursuant to 35 USC 112

Claims 13 and 28 have been responsively amended to remove the informalities noted by the Examiner. .

Amendments to the Claims Pursuant to 35 USC 103a

Claims 1 - 10, 12 - 25, and 27 - 30 were rejected as being obvious over the **Petrov et al** IEEE J.O.E. article in view of **Nabors et al.** U.S. Patent 5,781,571.

In regard to claim 1 the Examiner cited **Petrov** as disclosing an apparatus and method for generating narrow bandwidth picosecond optical pulses. The Examiner cited **Petrov** as including a mode-locked Ti:sapphire pulsed pump laser, an optical parametric amplifier pumped by a pump pulse train generated by

the pump laser, and an optical amplifier having an input coupled to an output of the optical parametric oscillator as shown in Fig. 1.

Petrov shows an optical parametric generator, indicated as OPG in Fig. 1, which is pumped by picosecond pulse originating from a Ti:Sapphire laser, amplified by an regenerative amplifier. The narrow bandwidth radiation is obtained by seeding the OPG with a pulse with 3 nanosecond duration obtained from a Spectra Physics MOPO system. **Petrov** is fundamentally different from the claimed apparatus. The generation of narrow bandwidth pico-second laser pulses in **Petrov** is achieved by a different means than that claimed. In **Petrov** a *seeded* optical parametric generator (OPG) is used, which is absent from the claimed invention. This difference is most strikingly distinguished by the fact that there is no common pumping laser in **Petrov**. **Petrov's** Spectra Physics MOPO system has its own independent laser pump. The mode-locked Ti:sapphire laser is pumped by an independent continuous wave Ar laser. The mode-locked Ti:sapphire laser run independently from the Spectra Physics MOPO, which makes timing between them a critical problem to be solved. The output of the Spectra Physics MOPO is a 3ns pulse. This is mixed in the OPA with the output of the Ti:sapphire laser/regenerative amplifier, which outputs a single 1ps pulse at 10 Hz rate. If the timing at the OPG between the 3ns pulse from the Spectra Physics laser and the 10 Hz 1 ps pulses from the Ti:sapphire laser/regenerative amplifier is right, then a 1 ps segment can be picked out from the spectrum of the 3ns pulse and amplified by the OPG. This timing can be difficult to achieve and may result in jitter in the output when not achieved.

Petrov's OPG is not an OPO, it is not resonant, and has no cavity. To reduce the spectral bandwidth this OPG, it is seeded with a 3 nano-second pulse from a Spectra physics MOPA. The Spectra Physics MOPA is very different from our oscillator design in that it is pumped by a nanosecond pump pulse, allowing gain during several roundtrips of a light pulse within in the oscillator within the duration of the pump pulse. The claimed oscillator is synchronously pumped by a train of pulses with pico-second duration, each individual pulse is substantially shorter than the time required to cover one round trip in the oscillator. The peak intensity within the pulses generated by the claimed oscillator is much higher, making is much easier to obtain successful amplification in the next amplification stage which in the claimed case is in our case OPA 15, in **Petrov's** case the OPG.

This difference is illustrated by the fact that in the claimed device it is possible to generate low power pico-second pulses just by using the oscillator. In **Petrov's** case this is impossible since the oscillator produces pulses with nano-second duration.

In the claimed apparatus the overall laser system is much simpler, since the claimed system is pumped by a single Nd:Yag laser and a simple double pass Nd:Yag amplifier. In the **Petrov's** apparatus two Nd:Yag lasers are necessary, as well as an Ar ion laser, the Tsunami picosecond oscillator and a quite intricate Ti:Sapphire regenerative amplifier. **Petrov's** system is actually by comparison much more complicated than the claimed apparatus.

Further, the timing requirements of the regenerative amplifier and the Spectra Physics MOPO make it impossible to pump both systems with a single Nd:Yag laser. It is likely that the cost of **Petrov's** system will be three times that of the claimed system and will be very hard to operate properly.

Turn to claim 1. While **Petrov** and the claimed apparatus has some elements in common with the claimed apparatus, what is not in common is that the **Petrov** apparatus does not have a single pump laser used to pump the optical parametric oscillator and also the optical parametric amplifier.

There are some mischaracterizations of the prior art in the Office Action. It should be noted that **Petrov's** OPG is not pumped by a pump pulse train as contended by the Examiner at page 3 line 1, but is in fact pumped by single pulses with a repetition rate of 10 Hz. Synchronous pumping is not possible in that case because at that rate by the time the pump pulse is repeated the oscillating light in the cavity has long since left the cavity or decayed.

On page 3, line 5 to 7 of the Office Action the Spectra Physics MOPO is directly compared with the claimed design "wherein a grating-mirror termination forms one end of the cavity and a cavity mirror forms the other end of the cavity, with an optical active non linear medium there between". The claimed oscillator cannot be legitimately so compared to the Spectra Physics design. The Spectra Physics laser is pumped by nanosecond pulses with a duration of several oscillator roundtrips. There is no picosecond pumping of the Spectra Physics laser. Also, the light pulses produced by the Spectra Physics laser are on the nanosecond timescale and not picosecond. Hence, the cavities cannot be

analogized.

Claims 2 – 5 depend directly or indirectly on claim 1 and are allowable therewith and for the additional limitations which each of the claims adds to claim 1.

In regard to claim 6 the Examiner contended that the **Nabors** tunable mirror works in exactly the same way as the claimed tunable mirror to adjust the resonant wavelength of the cavity. **Nabors** fails to show a tuning mirror which is rotatable about a center defined about the grating. The entirety of the teaching in **Nabors** in regard to the tuning mirror 45 and grating 43 of Fig. 3 is:

> "Referring to FIG. 3, in another embodiment 20A of an OPO in accordance with the present invention, a combination 41 of reflective diffraction grating 43, at grazing incidence to axis 23, and a mirror 45 are used as an output coupling device in place of partially reflective, partially transmissive element 26. A portion (OUT) of the oscillating signal light, here, is coupled out of resonant cavity 22 via the 0th order reflection of diffraction grating 43. Mirror 45 is **tiltable about an axis 47 (as indicated by arrow T)** for tuning signal light wavelength. Signal light bandwidth is narrowed by the grating. This configuration of mirror 45 and grating 43 is referred to by practitioners of the art as a "Littman" configuration or mode of the diffraction grating."

The tuning mirror 45 is not disclosed as being rotatable about a center defined about the grating so that the resonant wavelength of the cavity can be adjusted without changing the optical length of the cavity as called for by claim 6. On the contrary, tuning mirror 45 is rotatable about an entirely different axis T which is not at the center of the grating 43.

The Examiner contended that **Petrov** serves to narrow the bandwidth of each successive pulse that is reflected within the oscillator cavity, so using the **Nabors** grating-mirror termination in the cavity would continue to perform the

same narrowing.

It is not correct that **Petrov** narrows the bandwidth of each successive pulse that is reflected within the oscillator cavity as contended at page 3, lines 20 – 21 of the Office Action. This remark refers to the Spectra Physics MOPA oscillator, which is a nano-second system. The cavity is completely filled with light with a 3 nanosecond pulse and does not have an in-cavity pulse. Note that a one ns pulse is 30cm long! Also, the repetition rate of the Spectra Physics laser, 10 Hz, is very low so the light from the previous "shot" is completely removed or gone from the laser before the pump laser fires again. Hence, **Petrov** does not introduce a train of pulses in the optical parametric oscillator which trigger a multiple number of round trips of pulses in the cavity in which each reflection of a pulse from the grating-mirror termination narrows the bandwidth of the pulse. The cavity of the Spectra Physics MOPO is filled entirely with light in **Petrov.**

Claim 8 depends on claim 1 and is allowable therewith along with such further limitations that are introduced.

The Examiner admitted that **Nabors** does not address cavity stability, but contended without any supporting citation that the use of a concave cavity mirror to accomplish same is well known. **Petrov** does not support the assertion. The Examiner contended that such stabilizing arrangements flatten the wavefronts at the ends of the cavity, relative to the wavefront in the center of the cavity, and its use in the **Nabors** optical parametric oscillator cavity would have been obvious.

Nothing is shown in Nabors relative to the curvature of the end grating-mirrors to flatten the wavefront relative to the center of the cavity.

To applicant's knowledge there is no picosecond OPO design which exists that uses a lens or curved mirror in the center of the cavity and flat end mirrors. All prior art designs instead use curved end mirrors. This prior art arrangement causes the wavefront at the ends of the cavity to be curved and flat in the center of the cavity.

Claim 10 depends on claim 1 and is allowable therewith as further limited by the claim.

Claim 11 has been indicated as allowable and has been rewritten to stand in independent form.

Claims 12 – 15 depend directly or indirectly on claim 1 and are allowable therewith as further limited by the claim.

Claims 16 – 25 and 27 – 30 are method claims for operation of the claimed apparatus as set forth in corresponding claims 1 – 10 and 12 – 15 and are therefore allowable for the reasons set out above.

Claim 26 has been indicated as allowable and has been rewritten to stand in independent form.

Advancement of the claims to issuance is respectfully requested.

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on

May 18, 2004

by: Mike Navarro

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Signature

May 18, 2004

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